"SPELLCHECK": AUTONOMOUS EDUCATIONAL SPELLING AID

DIGITAL TECHNOLOGY DESIGN FOR PROMOTING SELF-REGULATING LEARNING IN STUDENTS WITH LEARNING DISABILITIES

A Thesis Prospectus
In STS 4500
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Bachelor of Science in Computer Engineering

By
Justin Guo

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Noah Beamon, Rachel Lew, Catlinh Nguyen, and Shymbolat Tnaliyev

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Catherine Baritaud, Department of Engineering and Society

Harry Powell, Department of Electrical and Computer Engineering

In the modern age, digital tools have been rapidly conforming into everyday lifestyles. Hamzi, Echantoufi, Khouna, and Ajana draw from their study that "almost half of students spend 18.75% of their free time using digital devices which are estimated to 1440 hours per year" (2021, p. 285). The COVID-19 pandemic has created a "paradigm shift in the way educators deliver quality education—through various online platforms", changing the role technology played in teaching (Pokhrel & Chhetri, 2021, p. 134). The usage of digital tools can be beneficial to the academic progress of students; Gissel and Andersen note in their study that introducing a computer-based reading support with text-to-speech functionality supported reading comprehension skills in the tested children (Gissel & Andersen, 2021, p. 297). Development for educational tools and technologies has skyrocketed since the beginning of the pandemic; "Venture and equity financing for education technology start-ups has more than doubled, surging to $12.58 billion worldwide last year from $4.81 billion in 2019" (Singer, 2021, para. 2). However, despite the uptake in investment into robotic educational technologies, adoption of these applications into the classroom environment have been slow because many of them do not show signs of academic benefit (Singer, 2021, para. 10). The main motivation behind the technical and STS projects is the rising push towards incorporating new technological devices into education.

The goal of the technical project is to create a prototype of an autonomous machine that allows the user to spell out objects with physical letter blocks and give instant feedback. Loosely coupled with the technical project, the STS project aims to create a design methodology for digital tools to promote self-regulating learning in children with learning disabilities. The technical project does not directly address teaching students with learning disabilities, but it does

provide insight into certain considerations a product must account for use in schools, such as design constraints for safety and the level of relative affordability.

The technical project will be done over the course of the current semester. Figure 1 below depicts the project completion dates of the technical project components as well as the presentation dates for the STS project prospectus, outlining how our team plans to reserve a large amount of time in the semester for system verification and testing. The goal of reserving time for

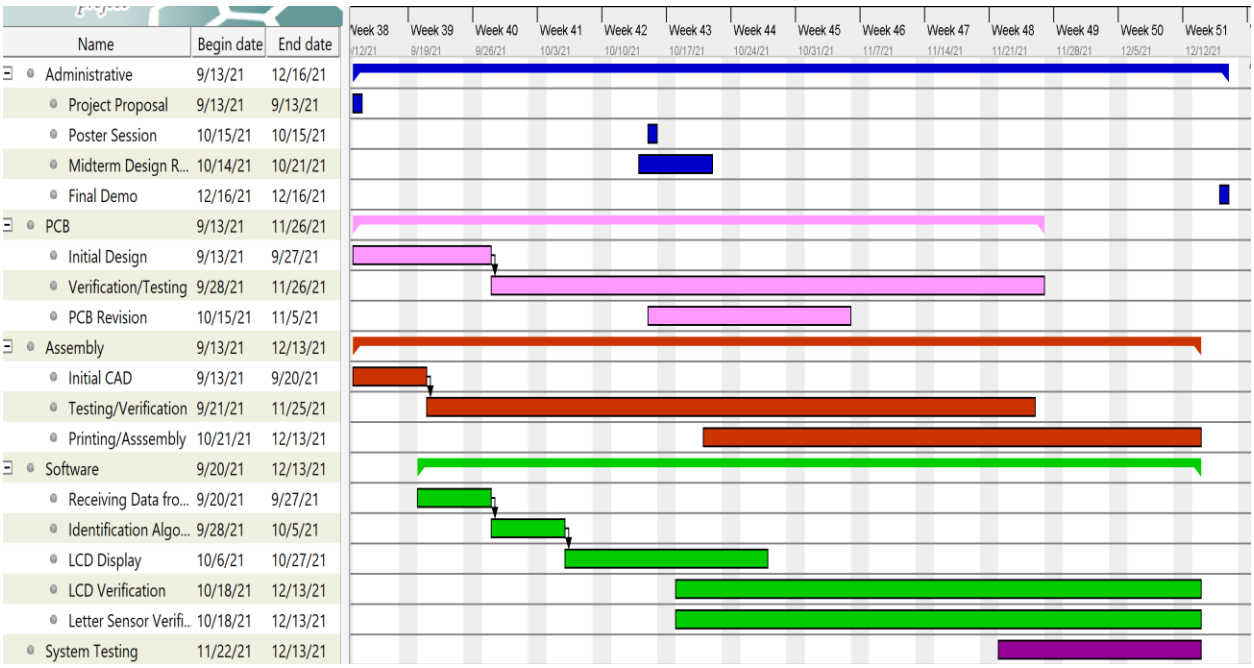

Figure 1. Gantt chart timeline. Graphical interpretation of the predicted progress of the technical and STS research projects over the 2021 fall semester. (Guo, 2021)

testing is to leave room for gathering feedback from our technical advisor, allowing us to change our game methodology as new requirements appear.

"SPELLCHECK": AUTONOMOUS EDUCATIONAL SPELLING AID

The team technical project, which our team named "SpellCheck", is a tool designed to teach children between the ages of five and seven how to spell words using physical letter blocks. The project displays images using an LCD screen and prompts the user to use letter

blocks to spell out the object, updating the image based on the combination of the letter blocks after the user places blocks. The physical letter block signals are decoded into digital letters by reading a set of magnets inside each block, which is dependent on the number and placement of the magnets. A MSP432P401R microcontroller, manufactured by TI Instruments, is the main software driver of the project.

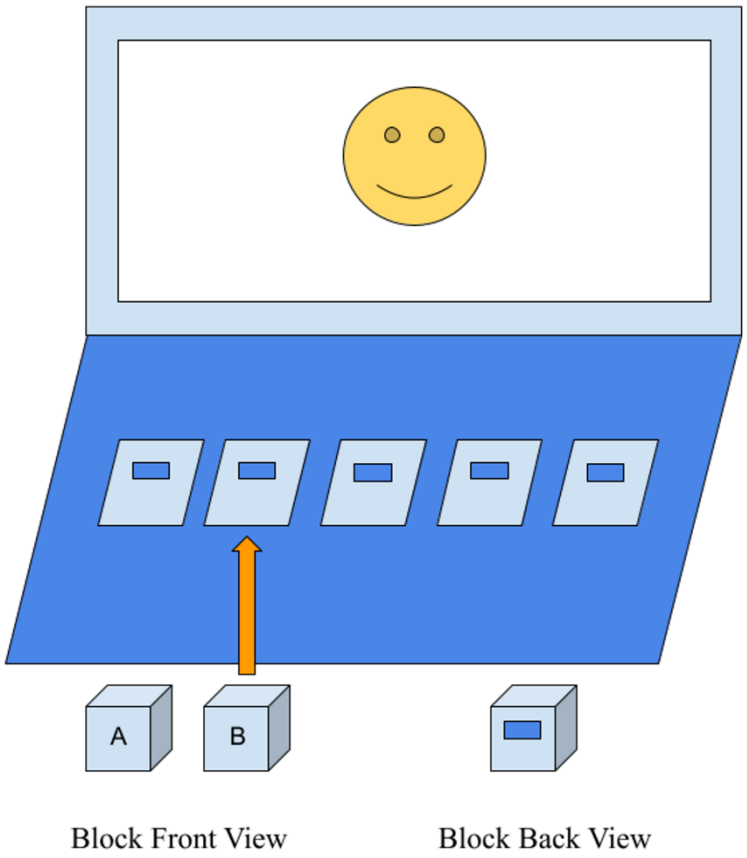

Figure 2: SpellCheck concept visualization. The diagram shows the letter blocks, where the user places them, and the LCD that displays an image. (Guo, 2021)

The microcontroller reads the analog inputs from the letter blocks the user inputs, converts the input into letters in software, and then updates the finite state machine of the system and updates the image on the LCD screen. A wall transformer is also included to provide power to the system, complete with bypass capacitors to prevent sudden discharges. Figure 2 displays the vision our group has for the technical project.

Debugging software, like Code Composer Studio, signal generators and analyzers, and the National Instruments laboratory are available for us to use during the development of the project.

The objectives of the technical project are to introduce an educational tool that uses an analog interface, is economically viable for classroom purchase, and is functionally viable for child play. The technical project stresses the integration of analog interfacing with the user through the use of physical letter blocks the user interacts with and sends as input into the device. Abdi and Cavus (2019) state that "exposing children to the use of mobile devices and other electronic devices specifically with Internet connectivity has a negative impact on them" (p. 30). For instance, Abdi and Cavus note that Internet connectivity can give children access to unwanted content, and that "Frequently using these devices can also negatively affect children's social lives and behavior" (p. 30). The physical interface of the design "enhances the educational value of children's play and enables physical objects to be effectively connected to virtual content of the learning material", allowing for stronger reinforcement learning (Abdi & Cavus, 2019).

In order to make the technical project functionally viable towards children, the project will also focus on ways to make the project engaging towards our target audience. "Gameplay is a significant reason for children's advancement and it is the primary impetus when structuring instructive exercises", implying that engagement with the game is additionally part of the objective in creating educational toys (Abdi & Cavus, 2019, pp. 31-32). Players are more likely to be engaged in the "game" when it provides adaptive challenges (Xu, Chen, Eutsler, Geng, & Kogut, 2020, p. 894), indicating that the design should be centered around matching the users with spelling out words of their own skill levels. The technical project will attempt to match words with a calculated skill level of the user in order to maximize the user's engagement with the game. Time spent with the game is "essential for students to get familiar and comfortable

with the digital platform or tool", which leads to a point where the device can be used by the user alone, without any other people interfering (Kang, 2018, p. 739).

Building and prototyping the technical project system will take place during the current semester. The technical project is a capstone project overseen by Professor Harry Powell, who is a professor in the Electrical and Computer Engineering department at the University of Virginia. The other team members are Noah Beamon, Rachel Lew, Catlinh Nguyen, and Shymbolat Tnaliyev, who are all fourth-year students in the Electrical and Computer Engineering department.

DIGITAL TECHNOLOGY DESIGN FOR PROMOTING SELF-REGULATING LEARNING IN STUDENTS WITH LEARNING DISABILITIES

Self-regulated learning in educational settings can be defined as the "active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment" (Lichtinger & Kaplan, 2015, p. 120). Harwood and Koyama (2020) describe self-regulated learning as a three-step cycle, depicted in Figure 3 on the right,

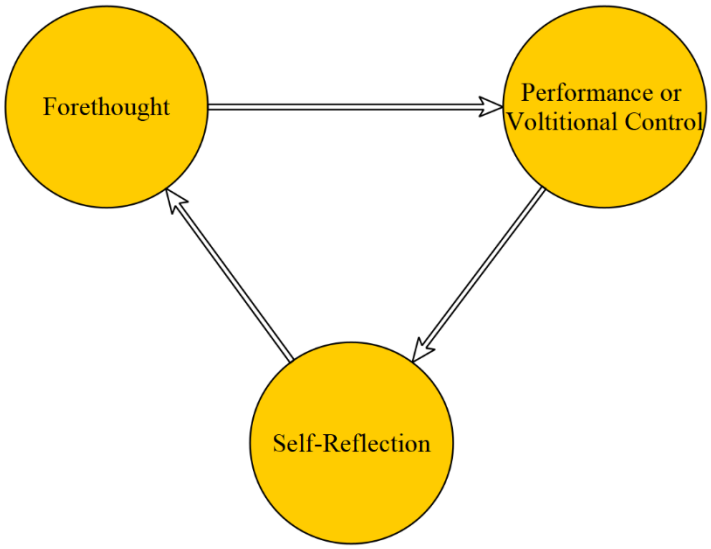

Figure 3: Model of self-regulated learning. Students set goals in the forethought step, take action in the performance step, and reflect on their actions in the final step. (Adapted by Guo (2021) from Harwood & Koyama, 2020)

showing how self-regulation leads to feedback cycles of attempting different strategies to reach a goal.

In students with learning disabilities, categorized as students who have characteristics that hinder their academic progress, a common experience is of academic failure and low expectations for success, preventing them from developing positive self-regulating learning techniques and ultimately lowers their efficacy to reach their goals and finish assignments (Lichtinger & Kaplan, 2015, p. 124). The continual experience of academic failures in students with learning disabilities are "associated with a sense of alienation from school, avoidance of challenging tasks, and self-handicapping strategies", making academic progress even more difficult to achieve (Lichtinger & Kaplan, 2015, p. 124).

By eighth-grade, students with learning disabilities greatly lag behind other students in their educational progress; "seventy one percent of eighth-grade students with learning disabilities (LD) score below basic in reading, compared to 18% of students without disabilities, making it difficult for them to gain content knowledge from texts" (Lauterbach et al., 2020, p. 227). Despite this, secondary content teachers often do not align their instruction with these students' needs. Lauterbach et al. (2020) notes that often times teachers "felt they were not responsible for students' inability to read texts … traditional methods (e.g., lecturing) could circumvent reading difficulties, and that students could learn content without learning to read text … they chose not to teach literacy skills even when they were aware students needed them", indicating that students with learning disabilities fall further behind due to the teacher's perspective on their role in educating their students (p. 228). This further reinforces the idea that without an established strong set of self-regulated learning techniques, students with learning disabilities will be challenged to develop self-efficacy in academic settings.

THE USAGE OF DIGITAL TECHNOLOGIES FOR SELF-REGULATED LEARNING

The STS research project will focus on the application of digital devices to promote positive self-regulating learning techniques in students with learning disabilities. To achieve this, the STS paper will examine the integration of digital devices into educational settings using the Social Construction of Technology framework (Pinch & Bijker, 1984, p. 416). The social construction of technology framework presents feedback from the relevant social groups, allowing the engineers of the artifact, in this case digital devices, to make changes until it reaches stabilization. Stabilization occurs when all of the social groups perceive the artifact in the same way, so that in the end all social groups associate the artifact with a certain design and with a set of usages (Pinch & Bijker, 1984, pp. 424-425). Figure 4, on page 8, shows the connections of relevant social groups that influence the design, development, and implementation of new digital

tools into school settings. Using the Social Construction of Technology framework, the STS project aims to analyze the relationship of these relevant social groups to create a methodology describing an effective and achievable method of integrating educational digital tools for students with learning disabilities. The project will also consider the acceptance of newly developed digital tools into education environments as well as the efficacy of using digital tools

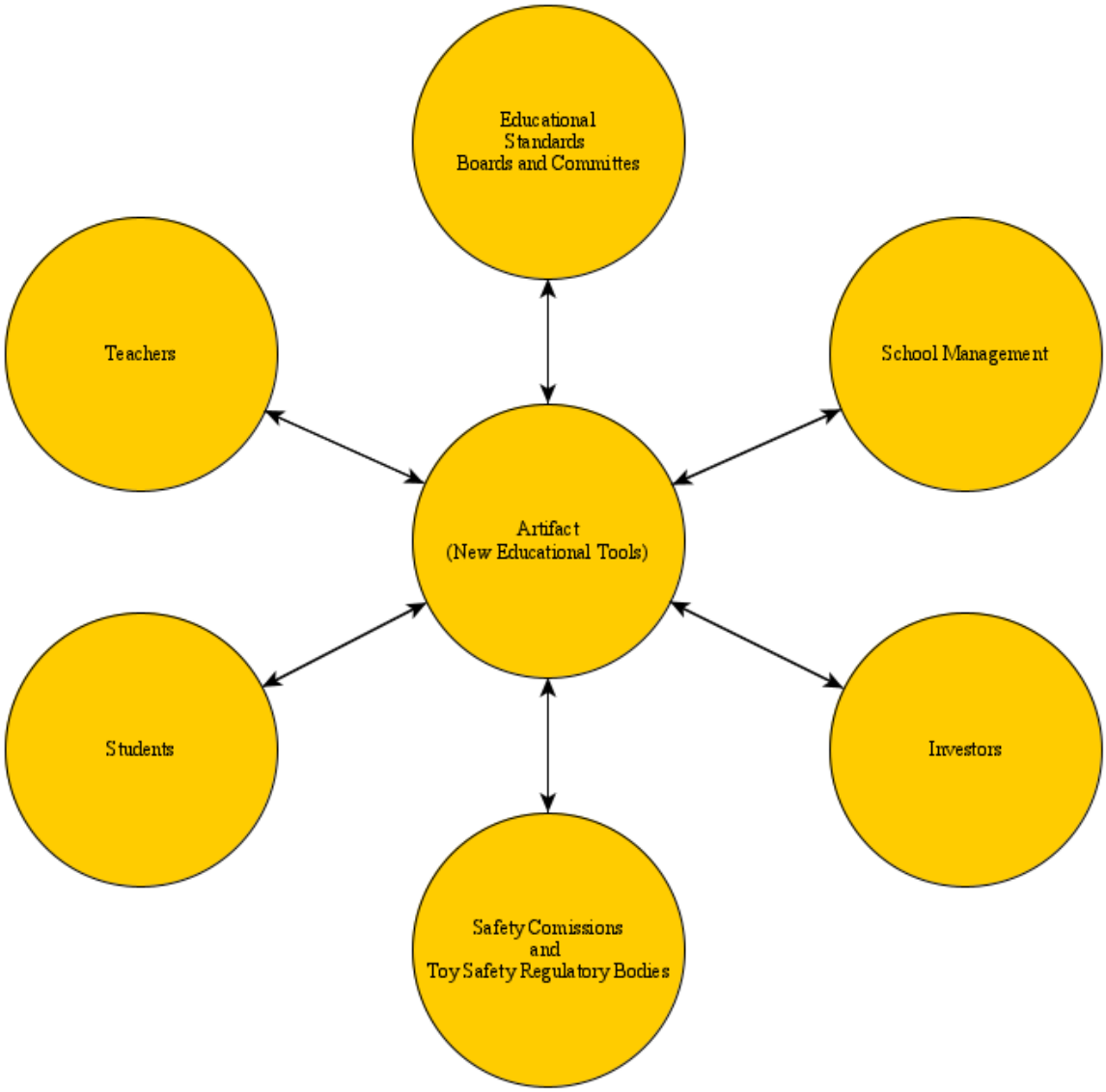

Figure 4: Adaptation of the Social Construction of Technology framework for new placing digital tools in context of educational settings. Each social group has a different interpretation of what an educational digital tool is, creating conflicts in the implementation of the artifact. (Adapted by Guo (2021) from Pinch & Bijker, 1984)

on self-regulating learning in children with learning disabilities. Without the strong integration of the artifact with educational environments, newly presented digital devices would not reach a large target audience and would thus not be a reasonable solution for addressing learning behavior.

In context of the development of educational tools, artifacts can be examined by their behavior to adapt to design requirements. Kucirkova and Flewitt (2020) writes that "that there are five principal external barriers that impede technology integration: lack of teacher confidence and skills; lack of time; lack of effective training; lack of well-organized access to resources; and technical problems", noting that accessibility to technology and the resources necessary to set up new systems up are considerations that digital technologies must design for (p. 136). Furthermore, Alelaimat et al. (2020) that many teachers agree with the integration of technology in early education, with one example of a report stating that "technology and digital media are important tools that all teachers should use in the 21st century. When I become a teacher in the future, I will definitely use technology in my classroom." (p. 306). However, technological integration with educational curriculums was different, as "most of the teachers interviewed … indicated that integrating technology into education did not seem to be a priority in their study plan … technology-related courses were not adequate, as these courses neither improved their technological skills nor increased their awareness about how to integrate technology into education" (Alelaimat et al., 2020, p. 308). This perspective highlights how the teacher is a prominent social group affecting the design of digital technologies for education; the efficacy of digital technologies is limited by the teacher's ability to understand and properly implement the intended system. The STS project will analyze the levels of accessibility and familiarity with new digital educational tools necessary to promote implementation.

Lauterbach et al. (2020) notes that three common themes from interviews with expert level teachers in educating students with learning disabilities are "understanding LD in the context of learning content", "developing literacy skills with an eye toward the future", and "integrating knowledge of content and strategy to further students' learning", indicating that the experts attempted to build positive self-regulated learning techniques in their students by setting goals and preparing the students to achieve them (p. 232). While not targeted towards students with learning disabilities directly, Hartwood and Koyama (2020) present one case of using digital technology to promote self-regulated learning; by appropriating the videoconferencing software Zoom, they shifted their writing center's operations online (p. 170). The one-on-one video sessions were designed to promote self-regulated learning behavior by issuing a tutorial preparation form, with space for writing down goals and reflections, and by sending out email copies of forms to students (Hartwood & Koyama). In contrast to the previous physical face-to-face model, students left "completing the learning cycle with their professor as the recipient of their reflections rather than the student" (Hartwood & Koyama, 2020, p. 170). The usage of Zoom here shows how an existing digital technology was adapted and modified to fit the writing center's needs. Zoom in this context does not present a direct solution to promoting self-regulated learning in students. It instead serves as an alternative method to use traditional teaching pedagogies, where students could still meet for one-on-one writing sessions. The STS research project will also explore the idea that digital technologies can indirectly promote self-guided learning in students with learning disabilities by providing more efficient ways to disseminate existing teaching practices.

Finally, the STS project will consider the possibility of digital technologies providing a direct solution. Another common theme among the teachers interviewed by Lauterbach et al.

(2020) was that the experts prioritized the students' literacy skills over the content of their teaching materials (p. 232). Digital devices designed to teach literacy skills could directly contribute to promoting self-regulating learning by removing the social pressures of early failures on students with learning disabilities.

THE MODERN CLASSROOM

The technical project will be a prototype of an educational tool designed to teach spelling to children, and the STS project will be a scholarly article focusing on the usage of digital technology to promote positive self-regulated learning behaviors in students with learning disabilities. With the current explosive trend of investment and research into educational digital tools, both projects ultimately attempt to explore new teaching pedagogies and modernize traditional classroom practices.

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